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AIR POLLUTANT EMISSION INVENTORY
FOR
MEMPHIS METROPOLITAN AREA

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Environmental Health Service

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A report of the emissions inventory of the Memphis Metropolitan Area is presented. The survey was intended to determine the present level of emissions and status of their control. Estimates are provided of total emissions of oxides of sulfur, oxides of nitrogen, hydrocarbons, carbon monoxide and particulate matter. The emissions are delineated with respect to source type, season of the year, and geographical distribution within the area. The report included the following sources: fuel combustion, transportation, solid waste disposal, industrial process losses, and evaporative losses.

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MEMPHIS METROPOLITAN AREA AIR POLLUTANT EMISSION INVENTORY

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U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

PUBLIC HEALTH SERVICE

Consumer Protection and Environmental Health Services

National Air Pollution Control Administration

Division of Air Quality and Emission Data

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1. Memphis and Shelby County Health Department
2. Arkansas Pollution Control Commission
3. Mississippi Air and Water Pollution Control Commission.

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PREFACE

This report which presents the emissions inventory of the Memphis Metropolitan area is another in a series of studies outlining the sources and emissions of air pollutants for major metropolitan areas in the country. These reports provide estimates of total emissions of oxides of sulfur, oxides of nitrogen, hydrocarbons, carbon monoxide and particulate matter. The emissions of these pollutants are delineated with respect to source type, season of the year as well as their geographical distribution within the area. These surveys are also intended to determine the present level of emissions and status of their control.

The general procedure for these surveys is based on the rapid survey technique. The Study Area is divided into grid zones that serve as the basis for locating sources and reporting their emissions. All sources of pollutants are divided into two subgroups - point and area sources. Sources that emit large quantities of air pollutants are considered individually and located specifically within the area. This latter group which generally contains about fifty to one hundred sources typically includes large industries, power plants, and central refuse burning facilities. The remaining multitude of sources are considered collectively as area sources and their emissions are reported as totals for grid zones. This category includes motor vehicles, home heating, smaller industries, on-site refuse burning, etc. The emissions in both cases are expressed in terms of tons of pollutants for an average annual, summer and winter day.

Emissions for the most part are estimated using various indicators of pollutant emissions and average emission factors that are related to these. This means that information and data are collected on fuel consumption, refuse burning rates, vehicle miles and gasoline consumption, as well as various production data. These are then translated into emission estimates by use of average emission factors. These factors, for the most part, represent average emission rates for a particular industry

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or fuel type. Because of the inherent difference in type of equipment, operating rates, control equipment, and efficiency of operation among the plants and fuel users within a given category, the application of the emission factors to any individual plant or even a smaller number of similar plants or processes may result in a discrepancy between the actual and the estimated emissions. However, the estimates of total pollutants from all sources in the study area should be reasonably accurate since the emission factors are based on average conditions.

INTRODUCTION

The information and data presented in this report were gathered in cooperation with the acknowledged state and local agencies during a survey conducted in June 1969. The data obtained in this study is, for the most part, representative of 1967 and emission estimates presented herein should be considered as showing the conditions during 1967.

For purposes of this survey, a Study Area consisting of three counties surrounding the city of Memphis was selected. This entire area covers some 1,800 square miles and included a 1967 population of about 835 thousand people. The Study Area was subdivided into 63 grid zones ranging in size from 25 square kilometers in the heavily populated and industrialzied areas to 100 square kilometers in the outlying areas.

Any individual source which had emissions of any one pollutant greater than 0.5 ton per average annual day was classified as a point source and located specifically in the aforementioned grid zones. Thirty-five individual sources fall into this classification and the remaining single sources were added to the area sources and reported as grid totals.

SUMMARY OF RESULTS

An estimated 641,000 tons of the five major pollutants are emitted annually in the Study Area. The breakdown of these emissions by type of pollutant and source category are summarized in Table 1. The following is a brief summary of pollutant emissions as presented in Table 1.

Sulfur Oxides	1967 Total = 77,600 Tons	
	Road Vehicles	2.1%
	Other Transportation	0.4%
	Utility Power Plants	70.2%
	Industrial Fuel Consumption	4.5%
	Solid Waste Disposal	0.1%
	Industrial Processes	22.7%
Particulates	1967 Total = 34,000 Tons	
	Road Vehicles	7.9%
	Other Transportation	3.5%
	Fuel Combustion	
	Industrial	1.8%
	Residential	0.6%
	Commercial	0.3%
	Utility Power Plants	44.1%
	Solid Waste Disposal	11.8%
	Industrial Process	30.0%
Carbon Monoxide	1968 Total = 401,000 Tons	
	Road Vehicles	79.8%
	Other Transportation	3.5%
	Solid Waste Disposal	3.1%
	Industrial Processes	13.6%

Hydrocarbons	1967 Total = 85,400 Tons	
	Road Vehicles	29.8%
	Other Transportation	3.4%
	Solid Waste Disposal	5.5%
	Evaporative Losses	56.8%
	Industrial Processes	4.5%
Nitrogen Oxides	1967 Total = 43,400 Tons	
	Road Vehicles	42.5%
	Other Transportation	5.2%
	Fuel Combustion	
	Industrial	10.7%
	Residential	3.2%
	Commercial	2.2%
	Utility Power Plants	31.4%
	Solid Waste Disposal	4.7%
	Industrial Process	0.1%

TABLE 1 SUMMARY OF AIR POLLUTANT EMISSIONS IN MEMPHIS STUDY AREA
1967 (TONS/YEAR)

Source Category	Sulfur Oxides	Partic-ulates	Carbon Monoxide	Hydro-carbons	Nitrogen Oxides
Transportation					
Road Vehicles	1,600	2,700	320,000	25,400	18,400
Other	300	1,200	14,000	2,900	2,200
Sub-Total	1,900	3,900	334,000	28,300	20,600
Fuel Combustion in Stationary Sources*					
Industry	3,500	600	20	10	4,600
Steam-Electric Utility	54,500	15,000	240	100	13,600
Residential	N	200	N	N	1,350
Commercial and Institutional	N	100	N	N	900
Sub-Total	58,000	15,900	260	110	20,400
Solid-Waste Disposal					
Incineration	N	1,900	4,900	2,200	1,100
Open Burning	100	2,100	7,400	2,500	900
Sub-Total	100	4,000	12,300	4,700	2,000
Industrial Processes	17,600	10,000	54,300	3,800	430
Evaporative Losses					
Dry Cleaning	--	--	--	1,660	--
Automobile	--	--	--	15,700	--
Gasoline Storage & Handling	--	--	--	31,100	--
Sub-Total	--	--	--	48,460	--
TOTAL ALL SOURCES*	77,600	34,000	401,000	85,400	43,400

*Totals have been rounded

N=Negligible

STUDY AREA

The Study Area for the emission survey of the Memphis Metropolitan Area consists of three counties--Crittenden County, Arkansas; DeSoto County, Mississippi; and Shelby County, Tennessee. The three-county area is located in the south western tip of Tennessee and extends into three states. Figure 1 shows the location of the Memphis Study Area relative to other large cities in its vicinity.

Figure 2 represents a more detailed drawing of the Memphis Study Area, showing the boundaries of the urban areas of Memphis and West Memphis. The Study Area occupies 1,840 square miles and contains an estimated 1967 population of 835,000 which is approximately a 16 percent increase since 1969 (Table 2). The population density map (Figure 3) shows that the heaviest population is concentrated in and near the city of Memphis.

Figure 1. Map of the state of Tennessee showing the Memphis study area and surrounding cities.

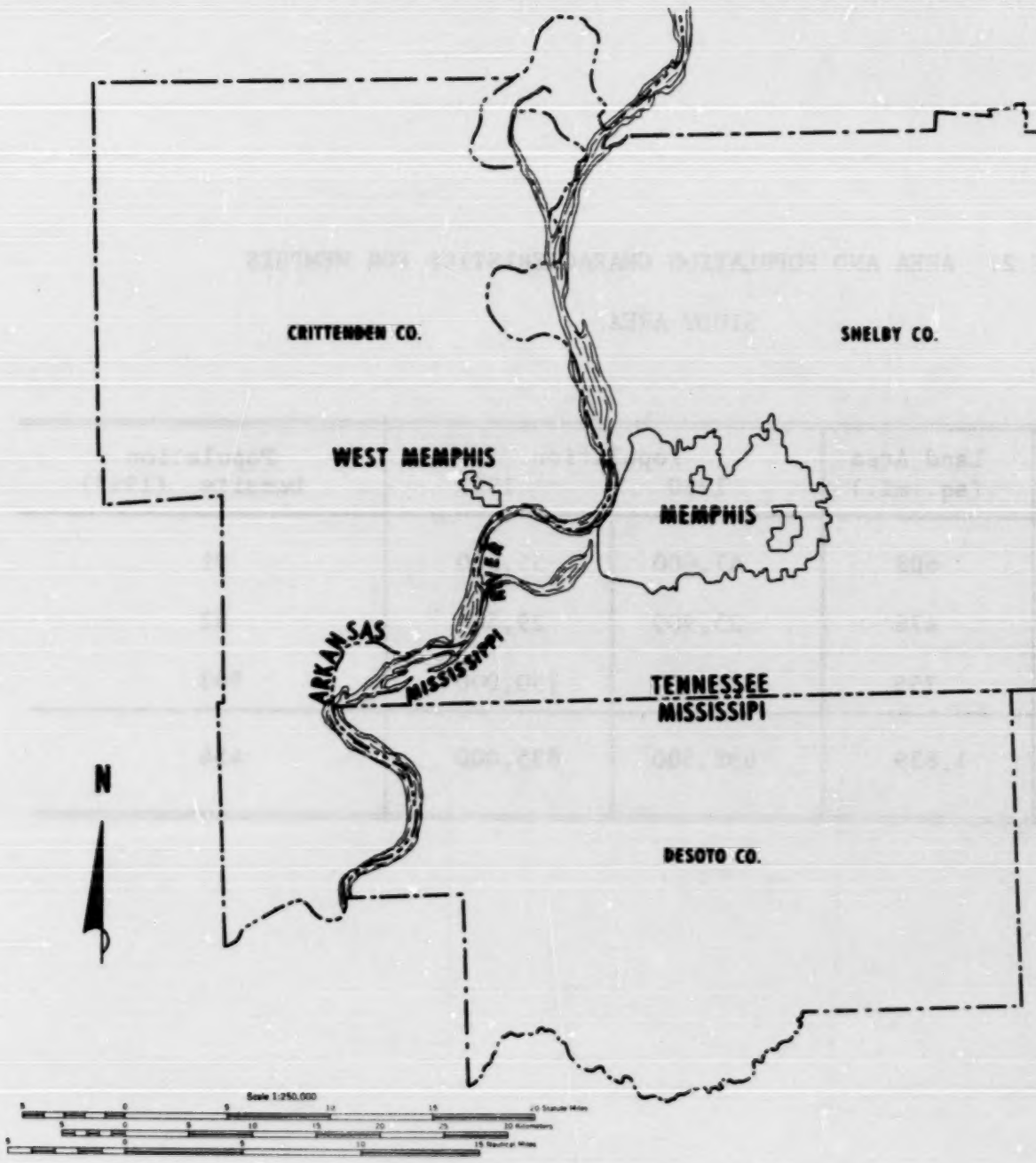

Figure 2. Detailed map of the Memphis study area.

TABLE 2. AREA AND POPULATION CHARACTERISTICS FOR MEMPHIS STUDY AREA

	Land Area (sq. mi.)	Population 1960	Population 1967	Population Density (1967)
Crittenden County	608	47,600	55,500	91
DeSoto County	476	23,900	29,500	62
Shelby County	755	627,000	750,000	993
Total Study Area	1,839	698,500	835,000	454

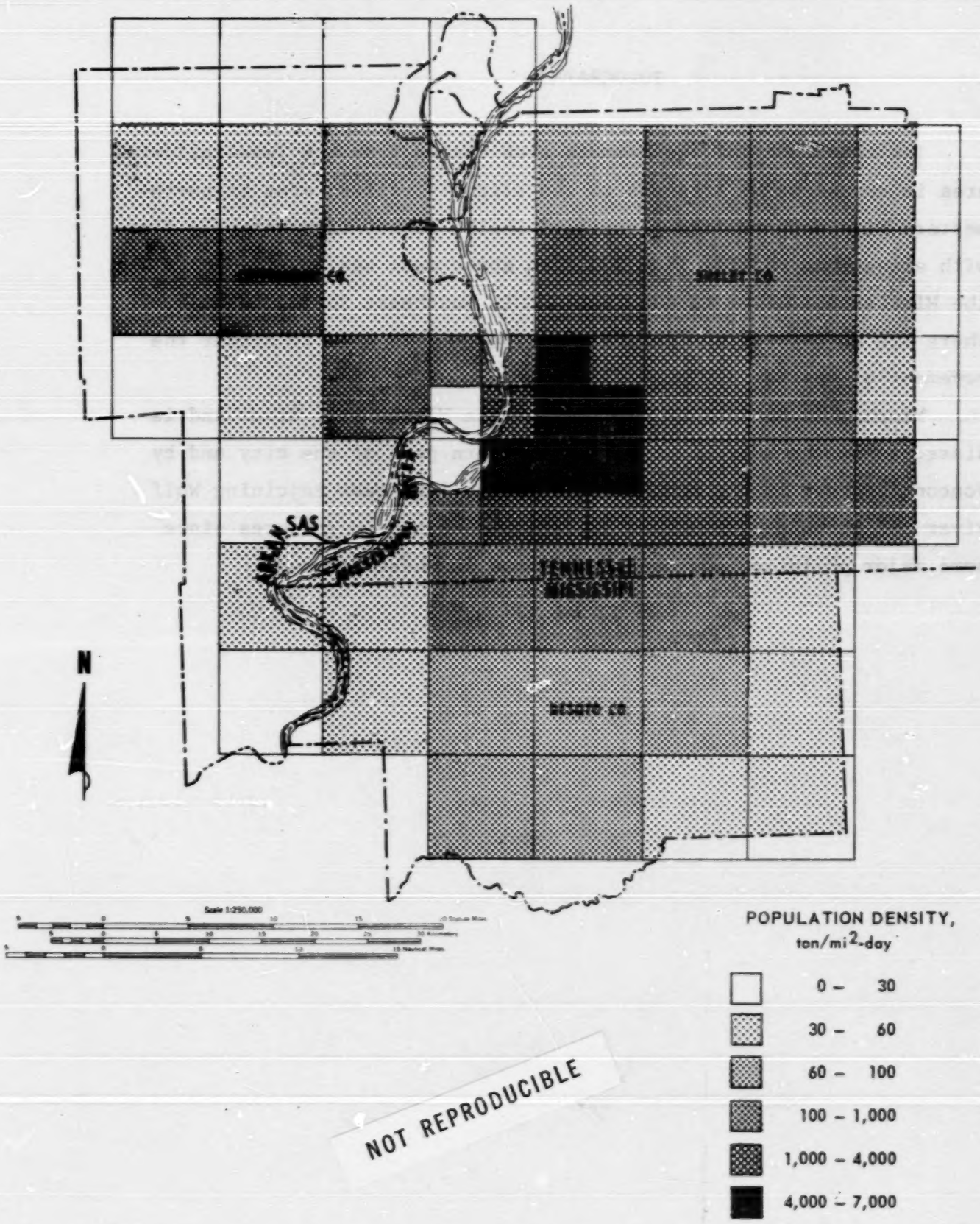

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Figure 3. Population density for Memphis study area, 1967.

TOPOGRAPHY

The topography of the Memphis area varies from the level alluvial area in east-central Arkansas to the slightly rolling area in northwestern Mississippi. The terrain of Shelby County is relatively flat with elevations ranging from 200 feet above mean sea level (MSL) along the Mississippi River to 400 feet MSL in southeast Shelby County. There are no natural obstructions in the Memphis area to hinder the movement of weather systems.

Memphis is bounded on the west by the Mississippi River and is dissected by the Wolf River in the northern part of the city and by Nonconnah Creek in the southern part. The low areas adjoining Wolf River and Nonconnah Creek are important topographic features since some major pollution sources are located in these areas.

GRID COORDINATE SYSTEM

Grid coordinates based on the Universal Transverse Mecator System were used in this study to show the geographical distribution of sources and emissions. As shown in Figure 4, the Study Area was divided into 63 grids of two different sizes - 25 and 100 square kilometers.

Different size grids are used to limit the number of grid zones and yet allow a satisfactory definition of geographical gradation of emissions in areas where the majority of pollution occurs. For this reason, the 25 square kilometer grids are used in the downtown areas and areas of high industrial concentration where the emission densities would change abruptly within short distances. In areas primarlily rural in nature, the use of small zones are not as important.

As illustrated in Figure 4 each grid line is identified by a coordinate number. The north-south and the east-west coordinates are expressed in meters.

The point sources in the Study Area are identified by both horizontal and vertical coordinates to the nearest 100 meters. The grids are identified by the coordinates of their geographical center.

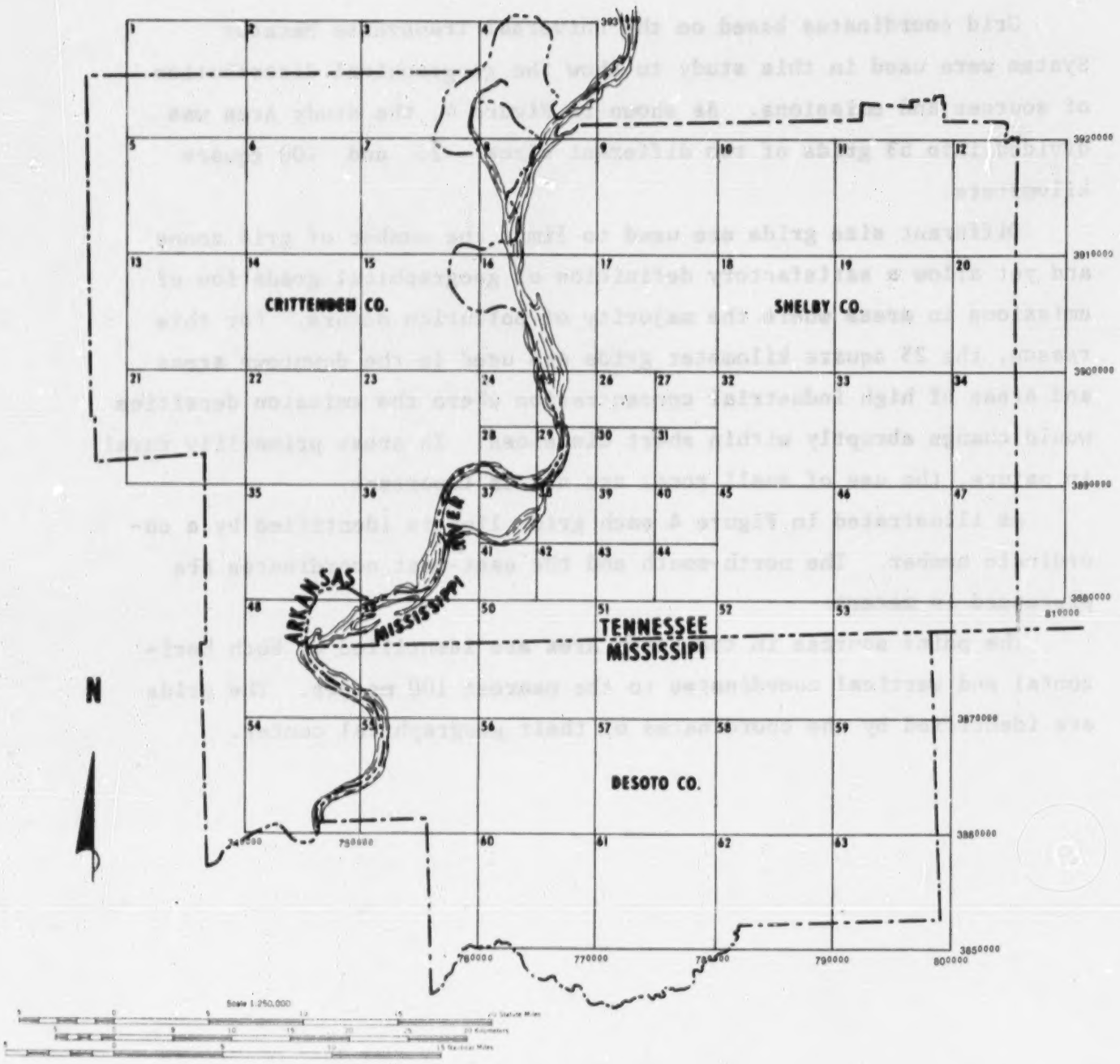


Figure 4. Grid coordinate system for the Memphis study area.

EMISSIONS BY CATEGORY

For the purposes of compiling the basic data and emission estimates, the air pollutant sources were classified into the following five categories:

1. Fuel combustion in stationary sources
2. Transportation
3. Solid Waste Disposal
4. Industrial Process Losses
5. Evaporative Losses

Each of these categories are considered individually in this section where data sources are given and methods of calculation are discussed.

It is important to note that the estimates presented herein are, in most cases, partial totals. This stems from the inavailability of emission factors as well as appropriate production data. The results should be viewed with these limitations in mind.

Fuel Combustion in Stationary Sources

Table 3 presents the fuel consumption within the Study Area. As shown in the table, natural gas is the primary fuel used. Approximately 960 thousand tons of coal, 14 million gallons of fuel oil and 37 billion cubic feet of natural gas were consumed in the Study Area. The breakdown of fuel consumption by user category and by jurisdiction is also shown in Table 3.

The steam-electric generating plant within the Study Area consumed over 99 percent of the total coal utilized by all sources. Industry is the other user of coal consuming less than 1 percent of the total.

Distillate fuel oil is consumed entirely by the steam-electric plant in the study area while residual oil is used entirely in industrial operations.

Natural gas, for all practical purposes is the only fuel used for residential home heating. There are homes heated by other fuels but they represent a very small percentage of the total.

Average values for the sulfur and ash contents of the fuels used are summarized in Table 4.[4,5]

TABLE 3. ANNUAL FUEL CONSUMPTION IN POLITICAL SUBDIVISIONS OF THE MEMPHIS STUDY AREA, 1967

Fuel	Jurisdiction	Industry	Steam-electric Utilities	Residential	Commercials & Institutional	Totals
Natural Gas Million Cubic Feet/Year	Crittenden	680	--	1,310	410	2,400
	DeSoto	160	--	120	40	320
	Shelby	35,800	21,200	21,400	15,000	93,400
	Totals	36,640	21,200	22,830	15,450	96,120
Coal, Tons/Year	Shelby	6,600	956,000	N	N	962,600
	Total	6,600	956,000	N	N	962,600
Fuel Oil 1000 gal./Year	Shelby	13,600	20	N	N	13,620
	Total	13,600	20	N	N	13,620

N = negligible

TABLE 4 SULFUR AND ASH CONTENT OF FUELS, 1967

Fuel	% Sulfur	% Ash
Coal	3.0	8.7
Residual Oil	3.0	--
Distillate Oil	0.2	--
Natural Gas	0.0008	--

Emissions from Fuel Combustion

Air pollutant emissions resulting from fuel combustion in stationary sources are summarized in Table 5. The emissions are presented for industrial, steam-electric utility, residential and commercial--institutional sources. Emissions from natural gas consumption account for approximately 28 percent of the total nitrogen oxide emissions and less than 1 percent of the total for any other pollutant.

Data Sources

Fuel consumption numbers were supplied by the local air pollution agencies which had obtained these numbers by jurisdiction with a breakdown by industry, residential, commercial and institutional source categories. The largest industrial users in each county, as well as the steam-electric plant were considered individually as single sources. The balance of the fuel was distributed to the three area source categories of fuel consumption: (1) residential (2) commercial--institutional and (3) industrial.

The amount of fuel burned for home heating purposes was calculated using the procedure described in the Rapid Survey Technique.[6] This method involves the use of such variables, as total annual degree days, average number of rooms per dwelling unit, and the number of units using each type of fuel.

TABLE 5 AIR POLLUTANT EMISSIONS FROM COMBUSTION OF FUELS IN STATIONARY SOURCES IN MEMPHIS STUDY AREA 1967 (TONS/YEAR)

Fuel User	Category	Sulfur Oxides	Particulates	Carbon Monoxide	Hydrocarbons	Nitrogen Oxides
Coal	Industrial	240	120	10	N	70
	Steam-Electric	54,500	14,800	240	100	9,500
	Residential	N	N	N	N	N
	Commercial & Institutional	N	N	N	N	N
	Totals*	54,740	14,920	250	100	9,600
Fuel Oil	Industrial	3,240	130	10	10	560
	Steam-Electric	N	N	N	N	N
	Residential	N	N	N	N	N
	Commercial & Institutional	N	N	N	N	N
	Totals	3,240	130	10	10	560
Gas	Industrial	N	330	N	N	3,930
	Steam-Electric	N	160	N	N	4,130
	Residential	N	220	N	N	1,350
	Commercial & Institutional	N	150	N	N	900
	Totals	N	860	N	N	10,300
GRAND TOTALS *		58,000	15,900	260	110	20,400

* Totals have been rounded

N=Negligible

Transportation

Four types of transportation sources of air pollution are considered in this survey--road vehicles, aircraft vessels and railroads. Road vehicles, which are by far the most significant source of air pollution in this category, are further subdivided according to type of fuel--gasoline or diesel.

Road Vehicles

The miles of travel by motor vehicles in the Study Area are summarized in Table 6.

Vehicle mile data for essentially all of the roads in Shelby County were supplied by Harland, Bartholemew and Associates for about 600 traffic zones. The vehicle miles were transferred from these traffic zones onto the previously mentioned grid system.

Vehicle mile data for all major arterials and highways in Crittenden County were obtained from traffic flow maps supplied by the local highway department. In DeSoto County vehicle mile information was not available and thus gasoline consumption[7] was used to find vehicular emsssions. The gasoline consumed in DeSoto County was apportioned on a grid basis by population.

The contribution to the total road vehicle pollution by diesel powered vehicles was determined by assuming that approximately 3 percent of the total vehicle miles traveled were by diesel vehicles. This was checked by estimating diesel fuel consumption in each county.[8] These emissions were apportioned on a grid basis by assuming they were proportional to gasoline emissions.

TABLE 6. VEHICLE MILES OF TRAVEL FOR ROAD VEHICLES IN MEMPHIS STUDY AREA PER DAY FOR 1967

Jurisdiction	(X 1000) Gasoline Vehicle Miles	Diesel (X 1000) Vehicle Miles	Total
Crittenden	780	20	800
DeSoto	520	20	540
Shelby	8,900	300	9,200
TOTALS	10,200	340	10,540

Emissions from road vehicles are a function of the speed at which the vehicle travels. Average speeds of 10-20 mph were assumed for downtown areas; 20-30 mph for the residential areas; and 30-45 mph for the rural areas.

From all transportation sources, road vehicles accounted for 84 percent of the sulfur oxides, 69 percent of the particulates, 96 percent of the carbon monoxide, 93 percent of the hydrocarbons and 89 percent of the nitrogen oxides. Gasoline powered road vehicles contributed a greater percent of all pollutants than diesel powered road vehicles. Emissions from transportation sources are summarized in Table 7.

Aircraft

Table 8 shows the air traffic activity at the two largest airports in the Study Area. The local air pollution agency contacted the two major airports in the Area in order to obtain their flight data for 1967. The breakdown of all flights at each airport by engine type is shown in Table 9. From all transportation sources aircraft accounted for 10 percent of the particulates 4 percent of the carbon monoxide, 5 percent of the hydrocarbons and 4 percent of the nitrogen oxides.

Railroads and Vessels

Railroads consume about 11 million gallons of diesel fuel per year in the Study Area. These figures were obtained from the various railroads in the Study Area. River vessels consume about 3 million gallons of diesel fuel per year. The air pollutant emissions arising from railroads and vessel sources are insignificant when compared to other transportation sources.

Solid Waste Disposal

Approximately 1.1 million tons of refuse were generated during 1967 in the Study Area. Table 10 presents a solid waste balance for the Memphis Study Area, showing the various methods of disposal and the quantities disposed of by each method. Refuse data for each of the counties were supplied by each local air pollution agency.

Dumps accounted for 61 percent of the total refuse disposed, open burning dumps 12 percent, wood waste burning 20 percent and other disposal methods 7 percent.

Table 11 show the air pollutant emissions from solid waste disposal in the Memphis - Study Area. A total of 12.300 tons of carbon monoxide, 4,000 tons of particulates. 4,700 tons of hydrocarbons and 2,000 tons nitrogen oxides were emitted from solid waste disposal practices. The largest sources were five open burning dumps one auto body incinerator, one commercial incinerator, and one wood waste incinerator in Shelby County and one open burning dump in DeSoto County.

Industrial Process Losses

Table 12 shows selected manufacturing establishments in the area by county for 1963.[9] It may be noted from the table that Shelby County accounts for the largest single percentage of every type of manufacturing. At least eighty-five percent of the establishments of any type are located in Shelby County. Emissions from industrial process losses are shown in Table 13.

Evaporative Losses

Three source categories are considered for evaporative losses--solvent evaporation from dry cleaning plants, gasoline storage and handling losses, and evaporative losses from automobiles.

Organic solvents emitted from dry cleaning plants were determined by assuming an emission rate of approximately 4 lb/yr./capita.[10] The resulting emissions were apportioned onto grids by population.

Automobile evaporative losses were calculated from vehicle mile data and the emissions apportioned onto grids using the same methods as for road vehicles.

Approximately 400 million gallons of gasoline were stored in Shelby County in 1967. The evaporative losses from this storage and

the subsequent handling of the gasoline were apportioned onto grids based on the location of the largest bulk terminals.

Evaporative losses from automobiles accounted for approximately 32 percent of the total hydrocarbon emissions, dry cleaning plants 4 percent and gasoline storage and handling 64 percent (See Table 14).

TABLE 7. AIR POLLUTANT EMISSIONS FROM TRANSPORTATION SOURCES IN MEMPHIS STUDY AREA, 1967 (TONS/YEAR)

Sources	Sulfur Oxides	Particulates	Carbon Monoxide	Hydrocarbons	Nitrogen Oxides
Road Vehicles					
Gasoline	1,100	1,500	319,400	23,900	15,900
Evaporation,	--	--	--	15,700	--
Diesel	500	1,200	700	1,500	2,500
Sub-Total	1,600	2,700	320,100	41,100	18,400
Aircraft					
Jet	N	350	400	100	240
Piston	N	50	13,100	1,900	480
Turboprop	N	N	N	N	N
Sub-Total	N	400	13,500	2,000	720
Railroad	210	600	320	740	1,200
Vessels	50	150	80	190	310
Total All Sources*	1,900	3,900	334,000	44,000	20,600

N = Negligible

*Totals have been rounded

TABLE 8. AIR TRAFFIC ACTIVITY AT MEMPHIS METROPOLITAN AND MILLINGTON NAVAL AIRPORT FOR 1967

	Memphis Metropolitan		Millington Naval	
	Itinerant Operations**	Local Operations	Itinerant Operations	Local Operations
Air Carrier	78,900	--	--	--
General Aviation	122,200	72,800	--	--
Military	4,500	3,100	60,000	*
TOTALS	205,600	75,900	60,000	*

* Included under Itinerant operations

** Operation-take off or landing

TABLE 9. AIR TRAFFIC ACTIVITY BY ENGINE TYPE FOR MEMPHIS STUDY AREA 1967

Engine Type	Number of Flights*
1 Engine Jet	10,500
2 Engine Jet	20,700
3 Engine Jet	5,700
4 Engine Jet	4,000
2 Engine Turboprop	1,600
4 Engine Turboprop	1,200
1 Engine Piston	76,700
2 Engine Piston	47,200
4 Engine Piston	3,100
TOTALS	170,700

* Flight combination take off and landing

TABLE 10. SOLID WASTE DISPOSAL IN MEMPHIS
STUDY AREA 1967 (TONS/YEAR)

	Total Refuse Generated	Incineration		Dumps	Open Burning		Auto Body Burning	Wood Waste Burning
		On-Site	Municipal		On-Site	Dumps		
Crittenden County	55,000	--	15,000	--	8,000	32,000	--	--
DeSoto County	37,000	--	--	--	6,800	27,200	3,000	--
Shelby County	1,000,000	19,000	--	667,000	--	74,000	17,000	223,000
TOTALS	1,092,000	19,000	15,000	667,000	14,800	133,200	20,000	223,000

TABLE 11. AIR POLLUTANT EMISSIONS FROM SOLID-WASTE DISPOSAL IN MEMPHIS STUDY AREA, 1967 (TONS/YEAR)

Category	Sulfur Oxides	Partic-ulates	Carbon Monoxide	Hydro-carbons	Nitrogen Oxides
Incineration					
Municipal	N	130	80	N	10
On-Site	N	170	420	10	50
Wood Waste	N	1,680	4,400	2,230	1,080
Sub-Total	N	1,980	4,900	2,240	1,140
Open Burning					
Dumps	90	1,060	5,660	2,000	730
On-Site	N	120	630	220	90
Auto Body	10	920	1,150	270	70
Sub-Total	100	2,100	7,440	2,490	890
GRAND TOTAL*	100	4,100	12,300	4,700	2,000

TABLE 12. SELECTED MANUFACTURING ESTABLISHMENTS IN THE MEMPHIS STUDY AREA

Type of Establishments	Number of Establishments by County			
	Crittenden	DeSoto	Shelby	Study Area
Food & Tobacco	1	1	76	78
Paper & Printing	2	--	38	40
Chemicals, Petroleum Products	--	--	39	39
Metal Production	5	--	40	45
Lumber Production	2	2	55	59
Stone, Clay & Glass	1	--	15	16
TOTALS	11	3	263	277

TABLE 13. AIR POLLUTANT EMISSIONS FROM
PROCESS LOSS SOURCES IN THE MEMPHIS STUDY AREA
1967 (TONS/YEAR)

Type of Industry	SO_x	PART.	CO	HC	NO_x
Refineries	600	--	19,000	3,800	430
Gray Iron Foundries	--	650	9,600	--	--
Lead Smelting	950	210	--	--	--
Rock Wool Production	--	100	--	--	--
Chromium Alloys Production	--	4,630	--	--	--
Chemical Plants	16,000	380	--	--	--
Ammonia Plants	--	40	25,700	--	--
Asphaltic Concrete	--	370	--	--	--
Feed & Grain Mills	--	3,230	--	--	--
Cotton Ginning	--	360	--	--	--
Alfalfa Mills	--	270	--	--	--
TOTALS*	17,600	10,200	54,300	3,800	430

*Totals have been rounded.

TABLE 14. HYDROCARBON EMISSIONS FROM
EVAPORATIVE LOSSES SOURCES IN MEMPHIS STUDY AREA
1967 (TONS/YEAR)

Source Category	Hydrocarbons
Dry Cleaning Plants	1,660
Automobile	15,700
Gasoline Storage & Handling	31,100
TOTAL	48,460

EMISSIONS BY JURISDICTION

In order to determine which counties are significant from an air pollution standpoint, emissions have been summarized for each of the three counties. Table 15 through 17 present the summary of emissions for each county.

The air pollutant emissions are far greater in Shelby County than in any of the other two counties. Since Shelby County is more heavily populated and contains the majority of all industry in the Area, this seems reasonable. Shelby County accounts for 99 percent of the total sulfur oxides in the Study Area, 94 percent of the particulates, 88 percent of the carbon monoxide, 89 percent of the hydrocarbons, and 93 percent of the nitrogen oxides.

TABLE 15 SUMMARY OF AIR POLLUTANT EMISSIONS IN CRITTENDEN COUNTY 1967 (TONS/YEAR)

Source Category	Sulfur Oxides	Particulates	Carbon Monoxide	Hydrocarbons	Nitrogen Oxides
Transportation					
Road Vehicles	120	200	21,800	1,800	1,400
Other	N	N	N	N	N
Sub-Totals	120	200	21,800	1,800	1,400
Fuel Combustion in Stationary Sources*					
Industry	N	N	N	N	80
Steam-Electric Utility	--	--	--	--	--
Residential	N	10	N	N	80
Commercial and Institutional	N	N	N	N	20
Sub-Total	N	10	N	N	180
Solid-Waste Disposal					
Incineration	N	130	80	N	10
Open Burning	20	300	1,700	600	220
Sub-Total	20	430	1,700	600	230
Industrial Processes	400	700	700	--	230
Evaporative Losses					
Dry Cleaning	--	--	--	100	--
Automobile	--	--	--	1,200	--
Gasoline Storage & Handling	--	--	--	NA	--
Sub-Total	--	--	--	1,300	--
TOTAL ALL SOURCES*	500	1,300	24,200	3,700	1,800

N=Negligible

NA=Information not available or not reported

* Totals have been rounded

TABLE 16 SUMMARY OF AIR POLLUTANT EMISSIONS IN DESOTO COUNTY
1967 (TONS/YEAR)

Source Category	Sulfur Oxides	Particulates	Carbon Monoxide	Hydrocarbons	Nitrogen Oxides
Transportation					
Road Vehicles	80	100	16,000	1,300	900
Other	N	N	N	N	N
Sub-Total	80	100	16,000	1,300	900
Fuel Combustion in Stationary Sources					
Industry	N	N	N	N	20
Steam-Electric Utility	--	--	--	--	--
Residential	N	N	N	N	20
Commercial and Institutional	N	N	N	N	N
Sub-Total	N	N	N	N	40
Solid-Waste Disposal					
Incineration	N	N	N	N	N
Open Burning	20	400	1,630	550	200
Sub-Total	20	400	1,630	550	200
Industrial Processes	--	20	300	--	--
Evaporative Losses					
Dry Cleaning	--	--	--	60	--
Automobile	--	--	--	800	--
Gasoline Storage & Handling	--	--	--	NA	--
Sub-Total	--	--	--	860	--
TOTAL ALL SOURCES*	100	500	17,900	2,700	1,100

N=Negligible

NA=Information not available or not reported

* Totals have been rounded

TABLE 17 SUMMARY OF AIR POLLUTANT EMISSIONS IN SHELBY COUNTY 1967 (TONS/YEAR)

Source Category	Sulfur Oxides	Particulates	Carbon Monoxide	Hydrocarbons	Nitrogen Oxides
Transportation					
Road Vehicles	1,400	2,400	282,200	22,300	16,100
Other	300	1,200	14,000	2,900	2,200
Sub-Total	1,700	3,600	296,200	25,200	18,300
Fuel Combustion in Stationary Sources					
Industry	3,500	600	20	10	4,500
Steam-Electric Utility	54,500	15,000	240	100	13,600
Residential	N	200	N	N	1,250
Commercial and Institutional	N	100	N	N	880
Sub-Total	58,000	15,900	260	110	20,200
Solid-Waste Disposal					
Incineration	N	1,850	4,820	2,240	1,130
Open Burning	60	1,400	4,110	1,340	470
Sub-Total	60	3,250	8,930	3,580	1,600
Industrial Processes	17,200	9,200	53,300	3,800	200
Evaporative Losses					
Dry Cleaning	--	--	--	1,500	--
Automobile	--	--	--	13,700	--
Gasoline Storage & Handling	--	--	--	31,100	--
Sub-Total	--	--	--	46,300	--
TOTAL ALL SOURCES*	77,000	32,000	359,000	79,000	40,300

N=Negligible

* Totals have been rounded

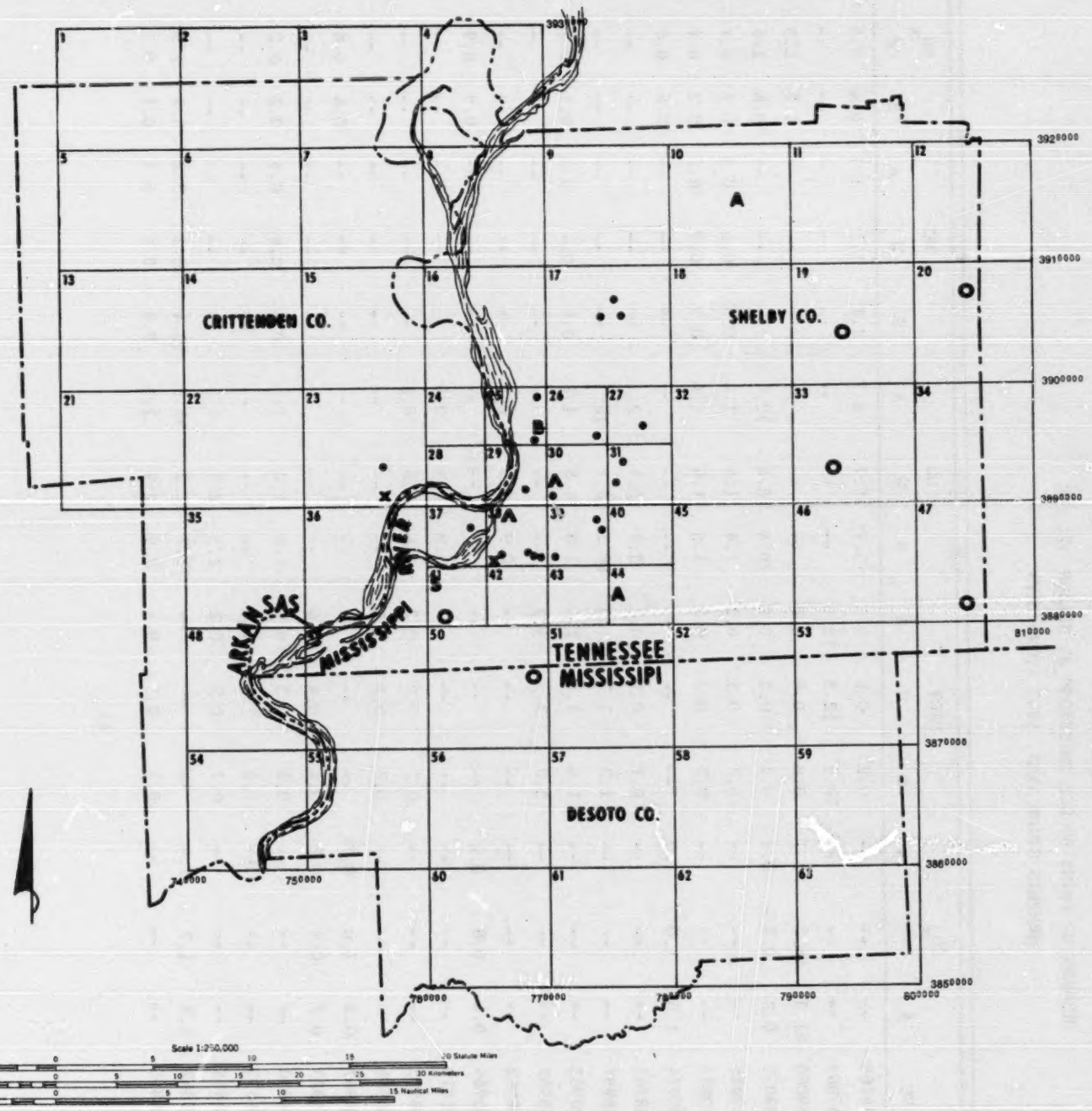
EMISSIONS BY GRID

For the purpose of modeling the air pollutant emissions in the Study Area, the resulting emissions were apportioned on the grid reference system shown in Figure 4.

The emissions of each pollutant were divided into two source subgroups--point and area sources. The 35 point sources were identified by source category, grid number and horizontal and vertical coordinates. Figure 5 shows the location of all major point sources in the Study Area. The point sources are presented in Table 18, along with emissions of sulfur oxides, particulates, carbon monoxide, hydrocarbons and nitrogen oxides for an average annual, winter and summer day. The appendix presents the method of calculating these three averages.

The emissions from all sources on the annual, winter and summer basis are shown in Table 19. The calculation of these averages is similar to that presented in the appendix for point sources.

FIGURE 5 POINT SOURCE LOCATIONS FOR MEMPHIS STUDY AREA



- Industry
- O Dump
- A Incinerator
- A Airport
- S Steam-Eletric Utility
- x Refinery
- B Auto Body Burning

TABLE 18

SUMMARY OF POINT SOURCE EMISSIONS BY SEASON FOR THE MEMPHIS STUDY AREA, 1967 (TONS/DAY).

Source Category	Grid	HC	VC	SO_x			PART.			CO			HC			NO_x		
				S	W	A	S	W	A	S	W	A	S	W	A	S	W	A
Airport	10	7860	39160	--	--	--	0.2	0.2	0.2	5.7	5.7	5.7	1.1	1.1	1.1	0.4	0.4	0.4
Industrial	17	7767	39066	--	--	--	12.5	12.5	12.5	--	--	--	--	--	--	--	--	--
Industrial	17	7748	39060	43.5	44.1	43.7	0.8	0.9	0.8	--	--	--	--	--	--	1.2	2.5	1.7
Industrial	17	7756	39075	0.2	0.5	0.3	0.2	0.3	0.2	70.4	70.4	70.4	--	--	--	0.8	1.6	1.1
Dump	19	7940	39048	--	--	--	0.3	0.3	0.3	1.4	1.4	1.4	0.5	0.5	0.5	0.2	0.2	0.2
Dump	20	8046	39074	--	--	--	0.3	0.3	0.3	1.4	1.4	1.4	0.5	0.5	0.5	0.2	0.2	0.2
Refinery	23	7575	38914	1.0	1.0	1.0	--	--	--	--	--	--	--	--	--	0.6	0.6	0.6
Industrial	23	7573	38941	--	--	--	0.1	0.1	0.1	2.1	2.1	2.1	--	--	--	--	--	--
Industrial	25	7689	38997	--	--	--	1.3	1.3	1.3	18.7	18.7	18.7	--	--	--	--	--	--
Auto Body Burning	25	7695	38965	--	--	--	1.4	1.4	1.4	1.8	1.8	1.8	0.4	0.4	0.4	0.1	0.1	0.1
Industrial	25	7691	38962	--	--	--	3.2	3.2	3.2	--	--	--	--	--	--	--	--	--
Industrial	26	7741	38962	--	--	--	--	--	--	0.9	0.9	0.9	--	--	--	--	--	--
Industrial	26	7778	38966	0.4	0.8	0.6	--	--	--	--	--	--	--	--	--	0.5	0.9	0.6
Industrial	29	7683	38919	--	--	--	--	--	--	0.9	0.9	0.9	--	--	--	--	--	--
Incineration	30	7703	38925	--	--	--	0.2	0.2	0.2	0.8	0.8	0.8	--	--	--	--	--	--
Industrial	30	7702	38906	--	--	--	0.8	0.8	0.8	--	--	--	--	--	--	--	--	--
Industrial	31	7767	38947	0.5	1.0	0.7	--	--	--	--	--	--	--	--	--	0.4	0.8	0.5
Industrial	31	7758	38923	0.8	0.8	0.8	0.4	0.4	0.4	--	--	--	--	--	--	--	--	--
Dump	33	7930	38930	--	--	--	0.3	0.3	0.3	1.8	1.8	1.8	0.6	0.6	0.5	0.2	0.2	0.2
Industrial	37	7635	38875	--	--	--	1.0	1.0	1.0	--	--	--	--	--	--	--	--	--
Industrial	38	7664	38865	--	--	--	0.2	0.2	0.2	2.5	2.5	2.5	--	--	--	--	--	--
Refinery	38	7657	38862	1.3	1.7	1.4	--	--	--	52.2	52.2	52.2	10.4	10.4	10.4	0.9	1.3	1.1
Incineration	38	7673	38898	--	--	--	0.5	0.5	0.5	2.9	2.9	2.9	0.9	0.9	0.9	0.1	0.1	0.1

TABLE 18 (cont.)

SUMMARY OF POINT SOURCE EMISSIONS BY SEASON FOR THE MEMPHIS STUDY AREA, 1967 (TONS/DAY).

Source Category	Grid	HC	VC	SO_x			PART.			CO			HC			NO_x		
				S	W	A	S	W	A	S	W	A	S	W	A	S	W	A
Industrial	38	7699	38862	--	--	--	--	--	--	0.5	0.5	0.5	--	--	--	--	--	--
Industrial	38	7684	38863	2.6	2.6	2.6	0.6	0.6	0.6	--	--	--	--	--	--	--	--	--
Industrial	38	7686	38862	--	--	--	1.1	1.1	1.1	--	--	--	--	--	--	--	--	--
Industrial	39	7703	38859	--	--	--	0.3	0.3	0.3	--	--	--	--	--	--	--	--	--
Industrial	39	7745	38878	--	--	--	1.2	1.2	1.2	--	--	--	--	--	--	--	--	--
Industrial	39	7744	38888	--	--	--	0.9	0.9	0.9	--	--	--	--	--	--	--	--	--
S.E. Utility	41	7601	38847	30.8	266.6	149.3	8.3	72.5	40.5	0.1	1.2	0.7	0.1	0.5	0.3	6.2	70.5	37.3
Dump	41	7620	38808	--	--	--	0.3	0.3	0.3	1.4	1.4	1.4	0.5	0.5	0.5	0.2	0.2	0.2
Airport	44	7756	38830	--	--	--	0.9	0.9	0.9	31.3	31.3	31.3	4.5	4.5	4.5	1.6	1.6	1.6
Dump	47	8040	38817	--	--	--	0.5	0.5	0.5	2.7	2.7	2.7	1.0	1.0	1.0	0.4	0.4	0.4
Dump	50	7693	38760	--	--	--	0.4	0.4	0.4	0.5	0.5	0.5	0.1	0.1	0.1	--	--	--
Industrial	53	7950	38708	--	--	--	0.1	0.1	0.1	0.9	0.9	0.9	--	--	--	--	--	--

TABLE 19 SUMMARY OF AIR POLLUTANT EMISSIONS FROM ALL SOURCES BY SEASON FOR MEMPHIS STUDY AREA, 1967 (TONS/DAY)

Grid	Land Area (sq. miles)	SO_x S	SO_x W	SO_x A	PART. S	PART. W	PART. A	CO S	CO W	CO A	HC S	HC W	HC A	NO_x S	NO_x W	NO_x A
1	38.6	--	--	--	--	--	--	0.2	0.2	0.2	--	--	--	--	--	--
2	38.6	--	--	--	--	--	--	1.7	1.4	1.5	0.3	0.2	0.2	0.1	0.1	0.1
3	38.6	--	--	--	--	--	--	1.7	1.4	1.6	0.3	0.2	0.2	0.1	0.1	0.1
4	38.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
5	38.6	--	--	--	--	--	--	1.2	1.0	1.1	0.2	0.1	0.2	--	0.7	--
6	38.6	--	--	--	--	--	--	4.0	3.2	3.6	0.6	0.5	0.6	0.3	0.3	0.3
7	38.6	--	--	--	0.7	0.7	0.7	2.3	2.0	2.2	0.5	0.4	0.5	0.2	0.2	0.2
8	38.6	--	--	--	--	--	--	--	--	--	0.2	0.2	0.2	0.2	0.2	0.2
9	38.6	--	--	--	--	--	--	5.8	4.8	5.3	1.3	1.2	1.2	0.4	0.4	0.4
10	38.6	--	--	--	0.3	0.4	0.3	15.1	13.3	14.2	6.6	6.3	6.5	1.2	1.3	1.2
11	38.6	--	--	--	0.2	--	--	2.0	1.6	1.8	0.9	0.9	0.9	0.2	0.2	0.2
12	38.6	--	--	--	--	--	--	0.8	0.7	0.7	0.4	0.4	0.4	--	--	--
13	38.6	--	--	--	0.4	0.4	0.4	3.7	3.2	3.5	0.7	0.6	0.7	0.3	0.3	0.3
14	38.6	--	--	--	0.5	0.5	0.5	3.1	2.8	3.0	0.7	0.7	0.7	0.3	0.3	0.3
15	38.6	--	--	--	0.1	0.1	0.1	5.9	4.9	5.3	0.9	0.7	0.8	0.4	0.3	0.4
16	38.6	--	--	--	0.1	0.1	0.1	0.9	0.8	0.9	0.2	0.2	0.2	0.2	0.2	0.2
17	38.6	43.9	44.7	44.2	13.8	13.9	13.8	95.7	91.1	93.4	8.4	7.7	8.0	4.0	6.1	4.7
18	38.6	--	--	--	0.1	0.1	0.1	7,8	6.4	7.1	2.9	2.7	2.8	0.6	0.6	0.6
19	38.6	--	--	--	0.3	0.3	0.3	5.7	5.0	5.3	1.9	1.7	1.8	0.5	0.5	0.5
20	38.6	--	--	--	0.3	0.3	0.3	2.3	2.2	2.2	1.0	1.0	1.0	0.2	0.1	--
21	38.6	--	--	--	--	--	--	1.3	1.1	1.2	0.2	0.2	0.2	0.1	0.1	0.1
22	38.6	--	--	--	0.2	0.2	0.2	9.0	7.4	8.1	1.3	1.1	1.2	0.6	0.5	0.6
23	38.6	1.1	1.0	1.0	0.8	0.8	0.8	20.6	17.2	18.9	2.4	2.0	2.2	1.8	1.8	1.8

TABLE 19 TOTAL ALL SOURCES (cont.)

Grid	Land Area (sq. miles)	SO_x			PART.			CO			HC			NO_x		
		S	W	A	S	W	A	S	W	A	S	W	A	S	W	A
24	9.65	--	--	--	--	--	--	0.1	0.1	0.1	0.3	0.3	0.3	--	--	--
25	9.65	0.6	0.6	0.6	7.0	7.0	7.0	31.8	30.0	30.9	3.7	3.4	3.5	2.3	2.2	2.2
26	9.65	1.0	1.4	1.1	1.1	1.1	33.3	27.6	30.5	10.0	9.1	9.6	9.6	3.7	4.1	3.8
27	9.65	0.8	0.8	0.8	0.8	0.8	0.8	35.4	29.0	32.2	8.9	8.0	8.3	3.6	3.4	3.5
28	9.65	0.1	0.1	0.1	0.2	0.2	0.2	13.4	11.0	12.2	2.0	1.7	1.8	1.1	1.0	1.0
29	9.65	0.7	0.7	0.7	1.2	1.2	1.2	78.5	64.4	71.4	11.8	10.3	11.1	4.2	3.8	4.0
30	9.65	0.8	0.8	0.8	2.2	2.1	2.1	111.3	91.3	101.3	21.2	18.8	20.0	6.6	6.1	6.3
31	9.65	2.7	3.1	2.8	2.3	2.2	2.3	125.1	102.5	113.8	22.0	19.0	20.1	9.2	8.6	8.8
32	38.6	1.0	1.0	1.0	1.1	1.1	1.1	82.2	67.3	74.8	19.9	17.8	18.9	6.7	6.2	6.4
33	38.6	--	--	--	0.4	0.4	0.4	3.0	2.8	2.9	1.6	1.6	1.5	0.3	0.4	0.3
34	38.6	--	--	--	--	--	--	0.6	0.5	0.5	0.3	0.3	0.3	--	--	--
35	38.6	--	--	--	0.2	0.2	0.2	2.6	2.3	2.4	0.5	0.4	0.5	0.3	0.3	0.3
36	38.6	--	--	--	0.3	0.3	0.3	0.6	0.5	0.5	0.1	0.1	0.1	0.1	0.1	0.1
37	9.65	0.6	0.6	0.6	1.3	1.3	1.3	0.1	0.1	0.1	0.1	0.1	0.1	0.8	0.8	0.8
38	9.65	5.3	5.7	5.4	6.3	6.3	6.3	144.2	129.7	137.0	29.8	28.3	29.0	8.1	8.0	8.0
39	9.65	0.7	0.6	0.7	3.0	3.0	3.0	57.9	47.4	52.6	12.6	11.4	12.0	3.8	3.6	3.6
40	9.65	0.5	0.5	0.5	0.8	0.8	0.8	47.0	38.5	42.8	11.2	10.1	10.7	3.5	3.4	3.4
41	9.65	30.8	266.6	149.3	8.6	72.8	40.8	1.8	2.8	2.3	10.0	10.5	10.3	6.4	70.8	37.6
42	9.65	0.6	0.5	0.5	1.0	1.0	1.0	65.3	53.5	59.4	11.6	10.1	10.9	4.5	4.0	4.2
43	9.65	0.3	0.3	0.3	0.2	0.2	0.2	14.3	11.7	13.0	3.7	3.4	3.5	1.2	1.2	1.2
44	9.65	0.4	0.4	0.4	1.1	1.1	1.1	34.4	33.8	34.1	7.2	7.2	7.3	2.3	2.5	2.4
45	38.6	0.5	0.5	0.5	0.6	0.6	0.6	36.4	29.8	33.1	6.2	5.3	5.7	3.2	3.4	3.2
46	38.6	--	--	--	--	--	--	2.9	2.4	2.6	1.1	1.0	1.1	0.2	0.2	0.2

TABLE 19 TOTAL ALL SOURCES (cont.)

Grid	Land Area (sq. miles)	SO_x			PART.			CO			HC			NO_x		
		S	W	A	S	W	A	S	W	A	S	W	A	S	W	A
47	38.6	0.1	0.1	0.1	0.5	0.5	0.5	5.7	5.2	5.5	2.0	2.0	2.0	0.6	0.6	0.6
48	38.6	--	--	--	0.2	0.2	0.2	1.8	1.5	1.6	0.3	0.2	0.2	0.1	0.1	0.1
49	38.6	--	--	--	0.1	0.1	0.1	2.3	1.9	2.1	0.5	0.5	0.5	0.1	0.1	0.1
50	38.6	--	--	--	0.5	0.5	0.5	6.9	5.7	6.3	4.2	4.1	4.1	0.5	0.6	0.5
51	38.6	--	--	--	0.1	0.1	0.1	8.1	6.7	7.4	3.4	3.2	3.3	0.6	0.6	0.6
52	38.6	--	--	--	0.2	0.2	0.2	6.3	5.3	5.8	1.6	1.4	1.5	0.4	0.4	0.4
53	38.6	--	--	--	0.1	0.1	0.1	1.0	1.0	1.0	0.2	0.2	0.2	--	--	--
54	38.6	--	--	--	0.4	0.4	0.4	0.8	0.6	0.7	0.1	0.1	0.1	--	--	--
55	38.6	--	--	--	0.1	0.1	0.1	3.1	2.6	2.8	0.5	0.4	0.4	0.2	0.2	0.2
56	38.6	--	--	--	0.1	0.1	0.1	4.1	3.4	3.8	0.6	0.5	0.6	0.3	0.2	0.2
57	38.6	--	--	--	0.1	0.1	0.1	4.4	3.6	4.0	0.6	0.5	0.6	0.3	0.2	0.3
58	38.6	--	--	--	0.1	0.1	0.1	5.9	5.0	5.4	0.9	0.7	0.8	0.4	0.3	0.4
59	38.6	--	--	--	0.1	0.1	0.1	3.0	2.5	2.8	0.4	0.4	0.4	0.2	0.2	0.2
60	38.6	--	--	--	0.1	0.1	0.1	4.5	3.8	4.1	0.7	0.6	0.6	0.3	0.3	0.3
61	38.6	--	--	--	0.2	0.2	0.2	8.1	6.7	7.4	1.2	1.0	1.1	0.5	0.5	0.5
62	38.6	--	--	--	0.1	0.1	0.1	3.6	3.0	3.3	0.5	0.4	0.5	0.2	0.2	0.2
63	38.6	--	--	--	0.1	0.1	0.1	3.0	2.5	2.8	0.4	0.4	0.4	0.2	0.2	0.2

EMISSION DENSITIES BY GRID

Emission densities on a grid basis were obtained by summing the annual area and point source emissions for each grid. This total, divided by the grid area, gives an emission density in tons per square mile per average day. Figures 6 through 10 present the emission density maps for the five surveyed pollutants. It is difficult to arrive at any valid conclusions from the emission density maps alone. For this reason, when they are analyzed, the detailed map of the Study Area and the population density maps should also be considered.

The emission density maps for carbon monoxide and hydrocarbons show that the greatest emissions occur within the urbanized area of Shelby County. Since transportation sources are the largest single sources of carbon monoxide, it would seem logical that in and near the city of Memphis carbon monoxide emissions should be the highest. Hydrocarbon emissions are highest in and around the city not only because of transportation sources but also because of the heavy concentration of dry cleaning establishments near the center city.

Sulfur oxides, particulates and nitrogen oxides emission densities were highest in grid 41 because of the large power plant located in this grid.

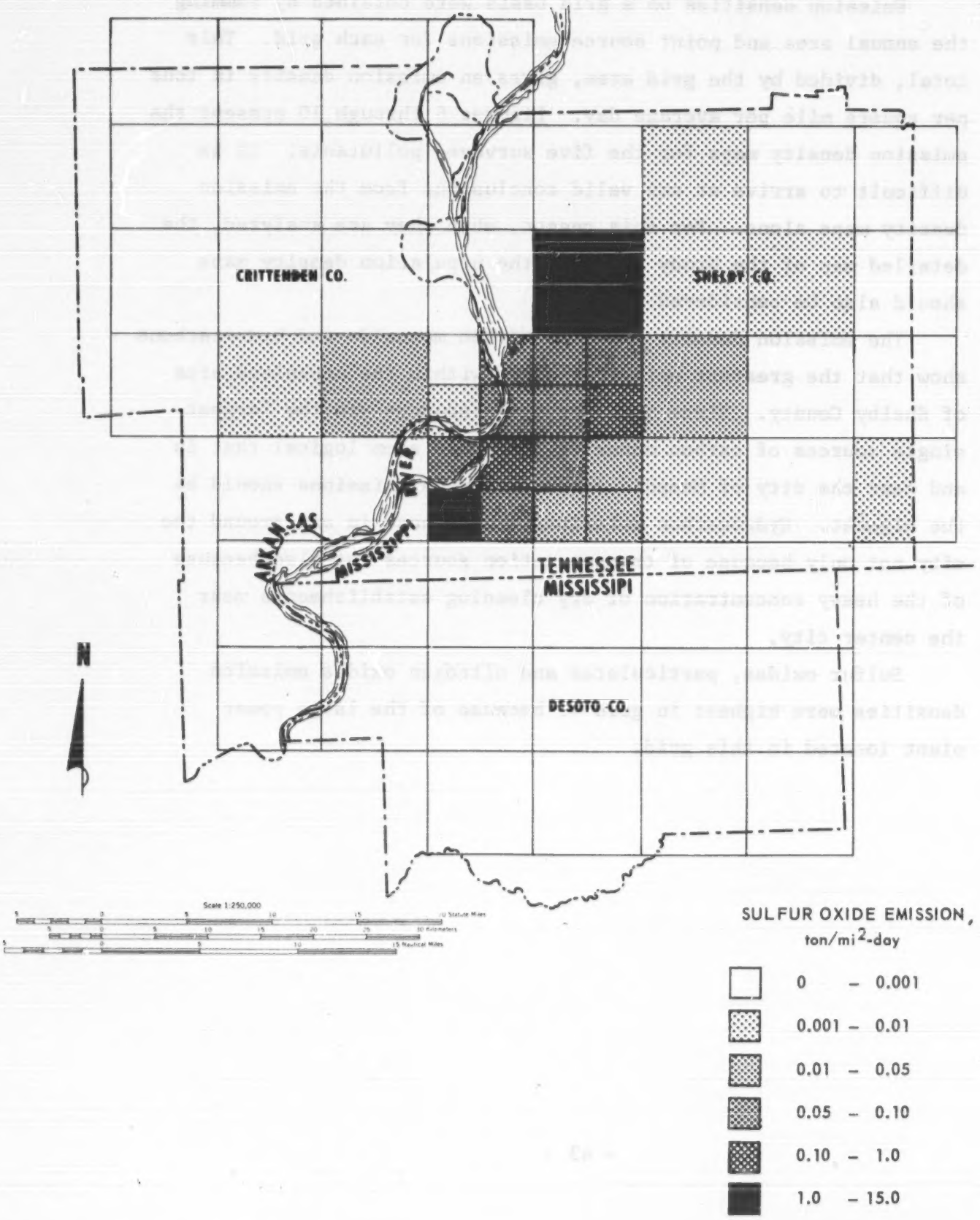


Figure 6. Sulfur oxide emission density from all sources for Memphis study area.

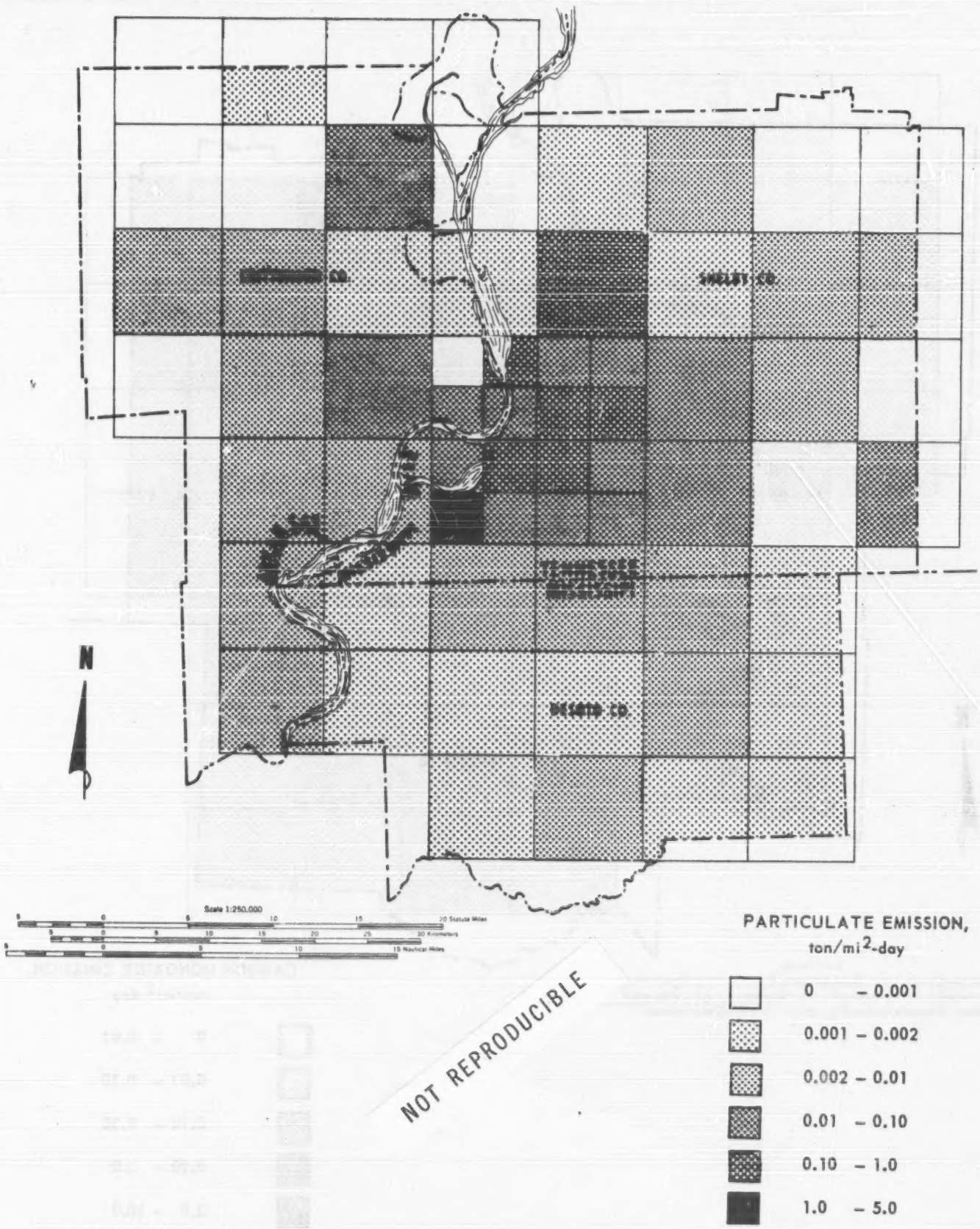
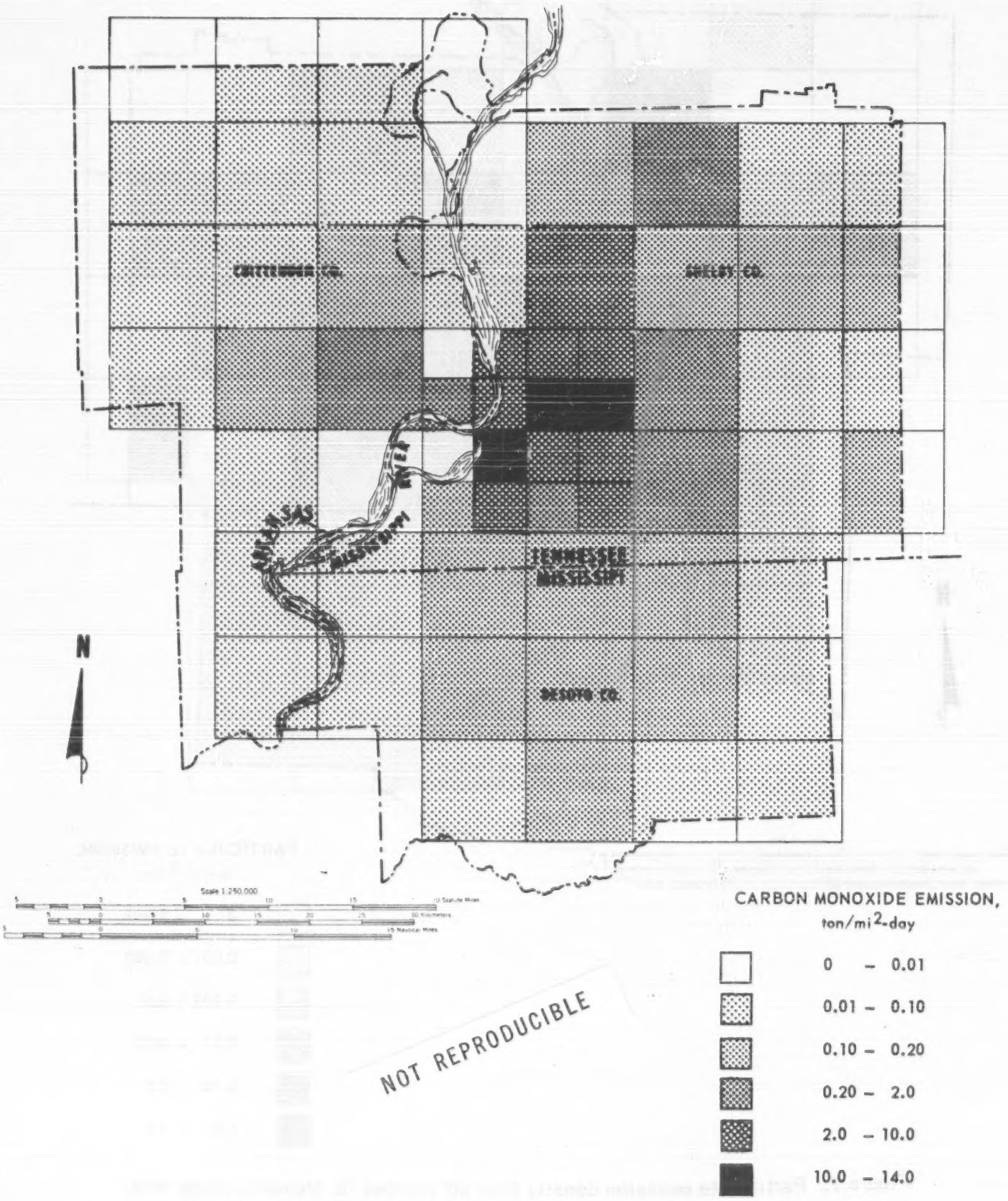


Figure 7. Particulate emission density from all sources for Memphis study area.



NOT REPRODUCIBLE

Figure 8. Carbon monoxide emission density from all sources for Memphis study area.

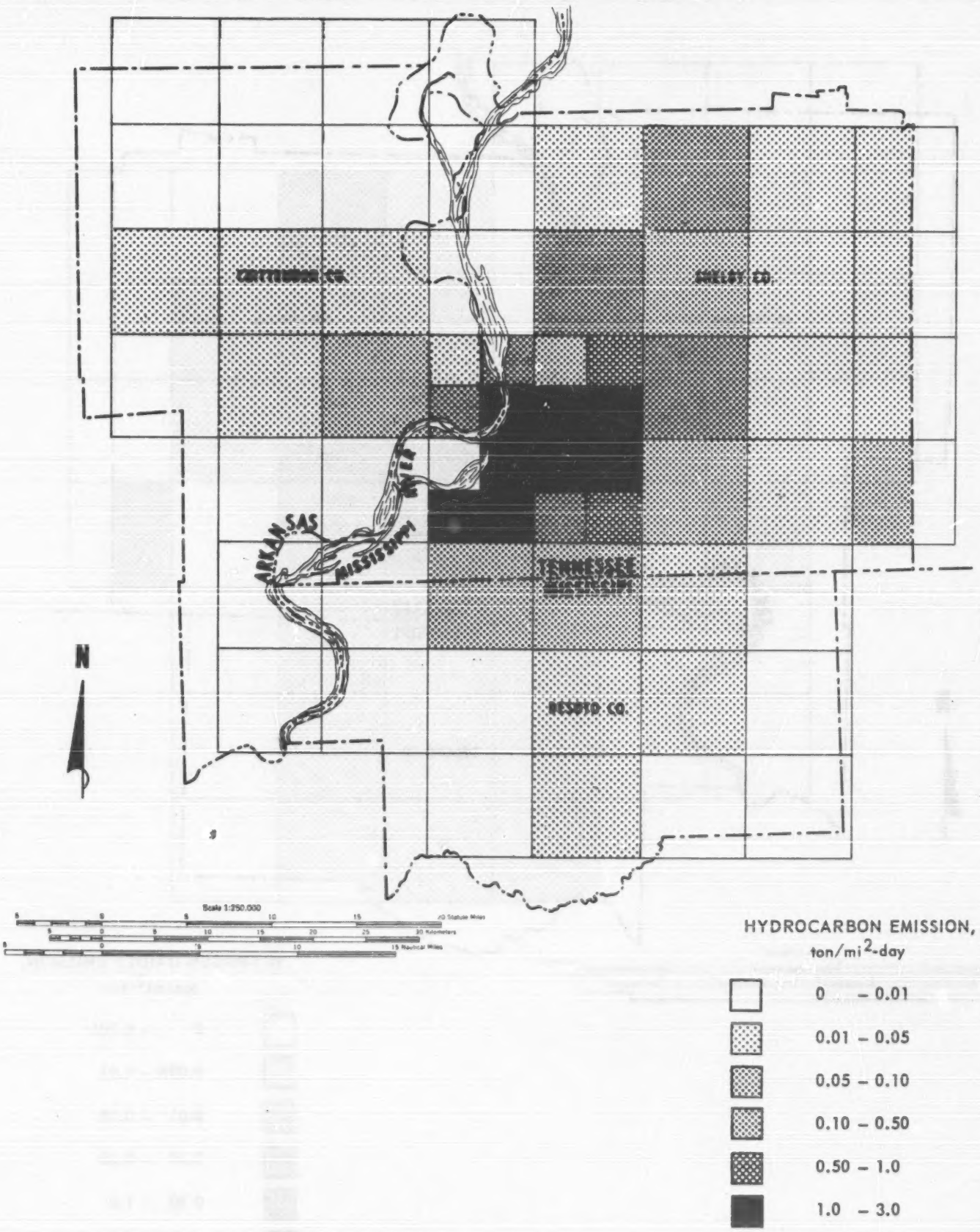


Figure 9. Hydrocarbon emission density from all sources for Memphis study area.

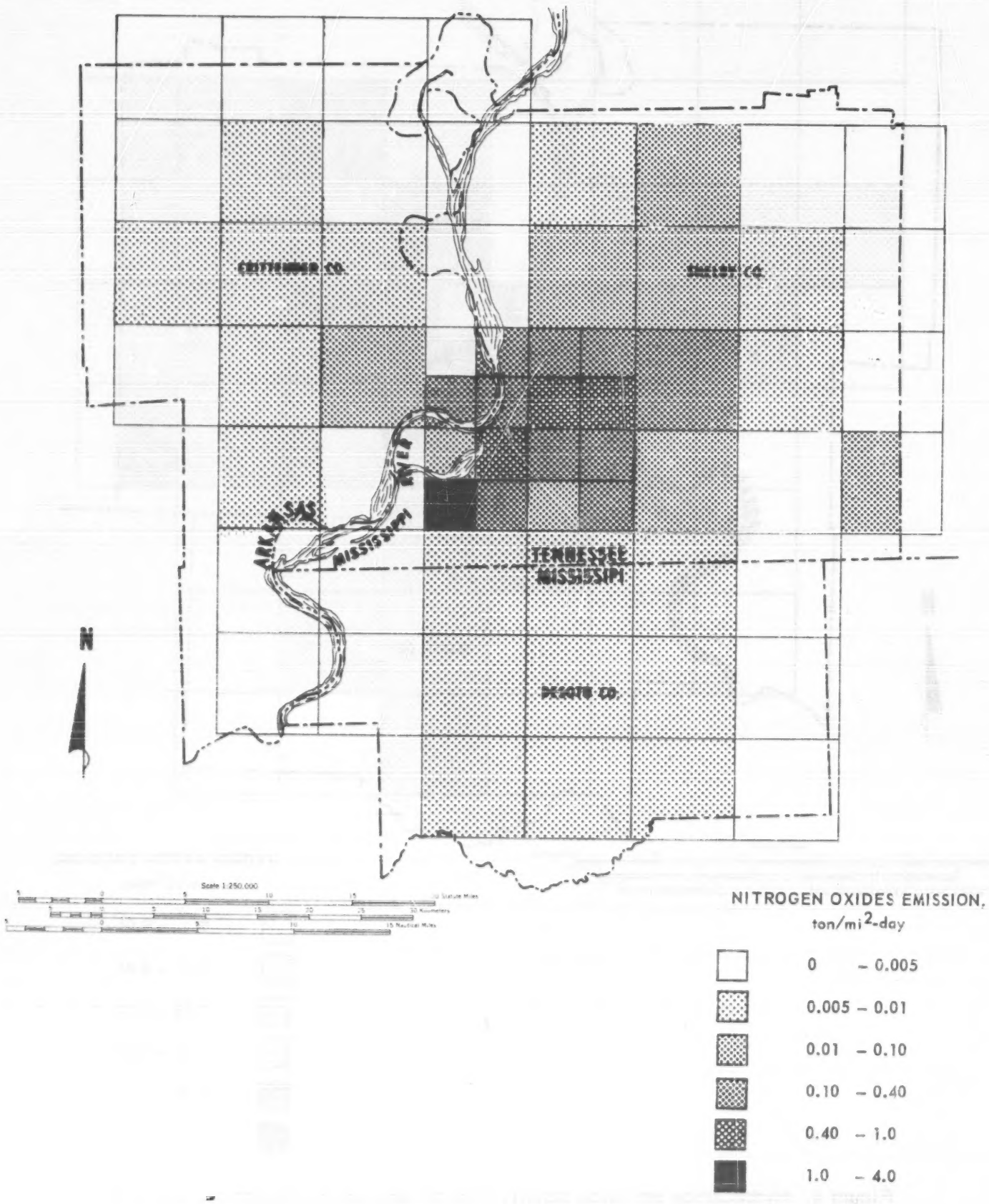


Figure 10. Nitrogen oxides emission density from all sources for Memphis study area.

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METHOD FOR CALCULATING SUMMER, WINTER AND ANNUAL

AVERAGE EMISSIONS FOR FUEL CONSUMPTION IN STATIONARY SOURCES

YEARLY AVERAGE (A)

$$A = \frac{\text{Fuel Consumed} \times \text{Emission Factor (E.F.)}}{\text{Days of Operation}}$$

e.g. A plant consumed 100,000 tons of coal in 1967 while operating 365 days. The total degree days for the area was 4,800 and 2,800 for the three winter months. The plant was estimated to use 15 percent of the fuel for space heating and 85 percent for process heating. From this information, the annual average emission for carbon monoxide would be the following:

$$A = \frac{100{,}000 \text{ Tons/year} \times 3 \text{ lbs. CO/Ton coal}}{365 \text{ Days/year} \times 2{,}000 \text{ lb./Ton}}$$

$$A = 0.41 \text{ Ton/Day}$$

WINTER AVERAGE (W)

$$W = \frac{\text{Fuel Consumed} \times \text{E.F.}}{\text{Days of Winter Operation}} \times \frac{\text{Winter Degree Days}}{\text{Total Degree Days}} \times \text{\% Fuel Used for space heating}$$

$$+ \frac{\text{Fuel Consumed} \times \text{E.F.}}{365} \times \text{\% Fuel used for process heating}$$

$$W = \left[\frac{100{,}000 \times 2{,}800}{90 \times 4{,}800} \times 0.15 + \frac{100{,}000}{365} \times 0.85\right] \frac{3}{2{,}000}$$

$$W = 0.49 \text{ Ton/Day}$$

SUMMER AVERAGE (S)

$$S = \frac{\text{Fuel Consumed} \times \text{E.F.}}{\text{Days of Summer Operation}} \times \frac{\text{Summer Degree Days}}{\text{Total Degree Days}} \times \text{\% Fuel Used for space heating}$$

$$+ \frac{\text{Fuel Consumed} \times \text{E.F.}}{365} \times \text{\% Fuel used for process heating}$$

$$S = \left[\frac{100{,}000}{90} \times \frac{0}{4{,}800} \times 0.15 + \frac{100{,}000}{365} \times 0.85\right] \frac{3}{2{,}000}$$

$$S = 0.35 \text{ Ton/Day}$$